

4.4 INTERNATIONAL INFORMATION

Several alternatives to the electroless copper process are being adopted more quickly abroad than in the U.S. This section discusses the world market for PWBs and the international use of MHC alternatives. It also discusses factors driving the international use of MHC alternatives, including economic, environmental and regulatory considerations.

4.4.1 World Market for PWBs

The total world market for PWBs is approximately \$21 billion (EPA, 1995c). The U.S. and Japan are the leading suppliers of PWBs but Hong Kong, Singapore, Taiwan, and Korea are increasing their market share. In 1994 the U.S. provided 26 percent of the PWBs in the world market, Japan 28 percent, and Europe 18 percent (EPA, 1995c). IPC estimates that domestic PWB imports are approximately \$500 to \$600 million annually (EPA, 1995c). Taiwan comprises approximately 30 to 35 percent of the import market with Japan, Hong Kong, Korea, and Thailand comprising 10 percent each. Domestic PWB exports were approximately \$100 million in 1993, which represents two to three percent of total domestic production (EPA, 1995c).

4.4.2 International Use of MHC Alternatives

The alternatives to the traditional electroless copper MHC process are in use in many countries abroad, including England, Italy, France, Spain, Germany, Switzerland, Sweden, Japan, China, Hong Kong, Singapore, Taiwan, and Canada. In addition, most of the suppliers of these alternatives have manufacturing facilities located in the countries to which they sell. One company provides its palladium alternative to Japan, France, Sweden, the UK, Canada, and Germany (Harnden, 1996). Another company, which provides a palladium alternative to electroless copper, provides both processes to England, Italy, France, Spain, Germany, Switzerland, China, Hong Kong, Singapore, and Taiwan. Presently, that company's electroless copper process is used more frequently than the palladium alternative (Nargi-Toth, 1996). However, restrictions on EDTA in Germany are making the use of the palladium alternative almost equal to the use of the traditional electroless copper process. Similarly, in Taiwan and China the use of the palladium process is increasing relative to the electroless copper process due to the high cost of water (Nargi-Toth, 1996). Internationally, one company reports its conductive polymer and organic-palladium processes make up approximately five percent of the world market (Boyle, 1996).

Another company provides its graphite alternative in Germany, England, France, Japan, Taiwan and Hong Kong, and is opening manufacturing facilities in both China and Malaysia within a few months (Carano, 1996). The company's graphite process is reportedly used more frequently in Europe than is its electroless copper process. However, in Asia, the electroless copper process is used more frequently (Carano, 1996).

Several suppliers have indicated that the use of their particular MHC alternative to electroless copper is increasing throughout the international arena. Some suppliers have indicated that the international usage of the electroless copper process is also on the rise but that the MHC alternatives are increasing in usage more rapidly than traditional electroless copper

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processes (Carano, 1996). A pollution prevention and control survey performed under the DfE PWB Project confirmed that the electroless copper is the predominate method employed in the U.S. The survey was conducted of 400 PWB manufacturers in the U.S.; 40 responses were received, representing approximately 17 percent of the total U.S. PWB production (EPA, 1995d). Eighty-six percent of survey respondents use the electroless copper for most of their products, 14 percent use palladium alternatives, and one respondent uses a graphite system (EPA, 1995d). The Pollution Prevention and Control Survey is discussed further in Chapter 1 of the CTSA.

Reasons for Use of Particular Alternatives Internationally

For the most part, the alternatives to the electroless copper process appear to be employed due to reasons other than environmental pressures. According to international manufacturers who participated in the Performance Demonstration Project, the most common reason for use of an alternative is economics. According to suppliers, some of the alternatives are in fact less costly than the traditional electroless copper process (see Section 4.2 for an analysis of the comparative costs of alternatives developed for the CTSA). An example of this is one company's graphite process, which reportedly costs less than the company's comparable electroless copper process (Carano, 1996). Furthermore, several of the performance demonstration participants in Europe indicated that their use of an alternative MHC process has resulted in increased throughput and decreased manpower requirements.

Some of the economic drivers for adopting alternatives to the electroless copper process internationally also relate to environmental issues. Several of the countries adopting the MHC alternatives have high population densities as compared to the U.S., making water a scarcer resource. As a result, these companies face high costs to buy and treat their wastewater. In Germany, for example, companies pay one cent per gallon to have water enter the plant and then must pay 1.2 cents per gallon to dispose of wastewater (Obermann, 1996). As a result, any alternative that offers a reduction in the use of wastewater is potentially more attractive from a cost-effectiveness standpoint. Several MHC alternatives allow wastewater to be reused a number of times, something that is not available when using the electroless copper process due to the high levels of chelators and copper that cannot be removed from the water except through chemical treatment (Obermann, 1996). Therefore, the costs of buying the water and paying to have it treated are reduced through the use of less water-intensive alternatives.

In some countries there are "pressures" rather than environmental regulations that have led to the adoption of an alternative to the electroless copper MHC process. Some countries have identified the use of EDTA and formaldehyde as areas of potential concern. For instance, in Germany there are restrictions on the use of the chelator EDTA that are making the adoption of non-EDTA using alternatives more attractive (Nargi-Toth, 1996). Some alternatives do not use formaldehyde and as such are used with more frequency than the electroless copper process in countries that are attempting to limit the use of formaldehyde (Harnden, 1996).

Barriers to Trade and Supply Information

The alternatives to the electroless copper process do not suffer from any readily apparent barriers to trade or tariff restrictions that would make their increased adoption more costly. The alternatives discussed above are all made from readily available materials. Therefore, if the

demand for these alternatives should increase there should be no problem with meeting the increased demand. Most of the suppliers of these alternatives have manufacturing facilities located in the countries to which they sell and so they face no tariffs from importing these chemicals. The companies that wish to use the particular alternative simply contact the manufacturer in their country to purchase the alternatives. Therefore, there are no trade barriers in the form of tariffs making one alternative more attractive to a potential purchaser (Carano, 1996; Nargi-Toth, 1996; Harnden, 1996). As was indicated above, most alternatives are available in the same countries so they all appear to be on equal footing in terms of availability and susceptibility to trade barriers.

4.4.3 Regulatory Framework

Most of the driving forces leading to the use of an alternative to electroless copper are related to the cost-effectiveness of the alternative. However, there are several regulatory mechanisms in place internationally that favor alternatives to traditional electroless copper processes. These include wastewater effluent requirements and water consumption issues, discussed below.

Wastewater Effluent Requirements

Suppliers and international performance demonstration participants report that economics, not chemical bans or restrictions on specific chemicals, are the leading cause for the adoption of an MHC alternative. However, wastewater effluent requirements for certain chemicals found in electroless copper processes are also speeding the adoption of other MHC processes. For example, in Germany the chemical EDTA is restricted so that it must be removed from wastewater before the wastewater is discharged to an off-site wastewater treatment facility. This restriction led one manufacturer to replace his electroless copper process with an organic-palladium process (Schwansee, 1996). This restriction is a national one so that all companies must adhere to it.

Also in Germany, the wastewater leaving a plant cannot contain copper in amounts in excess of 0.5 mg/L or any ammonia (Obermann, 1996). The German regulation on copper discharges is much more stringent than comparable regulations in the U.S., where facilities must at least comply with federal effluent regulations and are sometimes subjected to more stringent regulations from the states (EPA, 1995d). The federal effluent guidelines for copper discharges are 3.38 mg/l maximum and 2.07 mg/l average monthly concentration (EPA, 1995d). According to the Pollution Prevention and Control Survey discussed previously, 63 percent of the respondents must meet discharge limitations that are more stringent than the federal effluent limitations (EPA, 1995d). However, only 15 percent of the respondents had to meet effluent limitations that were as stringent as, or more stringent than, the German regulation (EPA, 1995d).

Water Consumption

As indicated above, water usage is a main concern in many of the international arenas that use these alternatives. While there are few direct regulations on the amount of water that can be used in a MHC process, the cost of buying and treating the water make a more water-intensive process less economical. In Germany, the high cost of purchasing water and discharging

wastewater greatly influences the decision of whether or not to use an alternative. The less water a process uses, the more likely it is that process will be used. In addition, in certain parts of Germany, local authorities examine plans for the MHC process and issue permits to allow use of the line. If the process that is proposed for use is too water-intensive, a permit will not be issued by the local authorities (Carano, 1996). In addition, local authorities sometimes give specific time limits in which an older more water-intensive process must be phased out (Carano, 1996). For example, one international participant in the Performance Demonstration Project uses an older electroless copper process for some of its products. The local authorities have given the company four years to cease operation of the line because it uses too much water (Obermann, 1996).

4.4.4 Conclusions

The information set forth above indicates that the cost-effectiveness of an alternative has been the main driver causing PWB manufacturers abroad to switch from an electroless copper process to one of the newer alternatives. In addition to the increased capacity and decreased labor requirements of some of the MHC alternatives over the non-conveyorized electroless copper process, environmental concerns also affected the process choice. For instance, the rate at which an alternative consumes water and the presence or absence of strictly regulated chemicals are two factors which have a substantial affect on the cost-effectiveness of MHC alternatives abroad. Finally, in some parts of Germany, local authorities can deny a permit for a new MHC process line if it is deemed too water-intensive, or require an existing MHC process to be replaced. While environmental regulations do not seem to be the primary forces leading toward the adoption of the newer alternatives, it appears that the companies that supply these alternatives are taking environmental regulations and concerns into consideration when designing alternatives to the electroless copper process.

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